A numerical approach for predicting the impact of vascular architecture on blood flow during ischemic repair

Stephanie Ann Wood[1], Shilpi Ghosh[1], Kevin Jones[1], Gabriel Gruionu[2], Trevor Cardinal[1]. [1]Biomedical Engineering Program, California Polytechnic State University, San Luis Obispo, CA, [2]W.L. Gore and associates, Inc, Flagstaff, AZ

Chronic ischemia results in vascular remodeling characterized by angiogenesis and arteriogenesis as well as reduced resting and hyperemic blood flows. Previous investigations have demonstrated impaired vasoactivity of intramuscular arterioles. However, the impact of vascular growth on blood flow is unknown. The goal of this study was to determine how changes in vascular architecture following arterial occlusion impact blood flow in hindlimb skeletal muscle. Vascular network characteristics were obtained from photomicrographs of India ink casts of the mouse gracilis anterior muscle with and without femoral artery occlusion. Quantitative systems-level network properties were obtained using Horton's Law of Stream Numbers and the diameter-defined Strahler method. The Hagen-Poiseuille equation and conservation of mass were used to solve for flow and pressure throughout the network. The diameter, length, and vessel quantity of control networks were consistent with Horton's Law. The remodeled data yielded a higher diameter ratio, but lower vessel length and quantity ratios compared to normal. Connectivity matrices indicated an overall increased branching in the remodeled vasculature while blood flow appears depressed in the ischemic muscle. Current efforts are aimed at deriving a quantitative expression to represent the effect of varying branch angles on flow resistance.